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The Philips three-tube Plumbicon colour camera

VISIT REPORT No. A-087

1964/64

THE BRITISH BROADCASTING CORPORATION

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Appraisal During a Visit to Paris, 20th September 1964

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1. INTRODUCTION

During the course of a meeting with representatives of N.V. Philips and Peto-Scott Ltd., an invitation was issued to engineers from the BBC to visit a colour television installation at Longchamp race course near Paris.

This race course is owned by a private syndicate, Société d'Encouragement pour l'Amélioration des Races de Chevaux en France; there are a number of well-appointed permanent grandstands and other buildings overlooking the course. In order to extend the facilities, the syndicate is experimenting with closed-circuit colour television, displayed in the bars, public rooms and betting offices of the race course. The installation as seen on 20th September 1964 consisted of two Philips three-tube plumbicon cameras, one mounted on the roof of the main grandstand opposite the finishing post, while the other was mounted on the roof of another building overlooking the paddock. The cameras were operated by cameramen from R.T.F., but the adjustment of the camera control units was supervised by staff from the Paris branch of the Philips ELA organisation. The pictures were coded and transmitted on the SECAM III system and the displays throughout the race course were C.F.T. SECAM receivers. The SECAM signals were also fed to a mobile R.C.A. TR.22 videotape recorder which re-played recordings of the previous race during each interval.

2. TECHNICAL DETAILS

The pictures seen on the public monitors were generally very poor. This was partly due to the fact that the monitors could not usefully be sited in positions where they did not receive an unduly large amount of ambient illumination. At one monitor, light falling on the face of the tube measured no less than 70 ft-Candles. This rendered the pictures very nearly colourless; only peak whites due to railings, number boards and architectural details could, as a rule, be seen, the rest of the picture appearing to be black.

In the control room, there were two Philips R,G,B monitors, incorporating 21 in. shadow-mask tubes, while a third colour monitor showed the SECAM colour picture. There was also a 21 in. black-and-white monitor which showed the compatible picture. Ambient illumination in the control room was of the order of 4 ft-Candles. The SECAM pictures were rather poor. Comparison with the R,G,B displays showed that the coding system was introducing considerable hue shift and de-saturation of the colours while subcarrier patterns on edges, "horizontal ladders", and some edge flicker were visible most of the time.

Of the two R,G,B monitors coupled directly to the camera outputs, the monitor connected to the camera overlooking the course showed pictures which were acceptable but not outstanding. This camera was fitted with an Angenieux 50 mm to 600 mm f/4.5 zoom lens. This particular camera was one of the earlier prototypes in which the plumbicon tubes were operating with the normal 300 V wall anode potential. The camera overlooking the paddock was a brand-new production model and the tubes operating with 600 V wall anode potential. In this case, the lens was an Angenieux 18 mm to 180 mm f/2.2 zoom lens.

The scene in the paddock which this camera was required to portray consisted of the usual grass enclosure surrounded by white railings but it also contained a number of London Plane trees, fairly closely planted together so that there were extremely high contrasts between the shadow under the trees and those parts of the white railings which were in direct bright sunlight. On occasions when the camera tilted up from the horses, the whole screen could be filled with fine details of the trees and since a 10 : 1 zoom lens was fitted to the camera, it was possible to obtain a very wide variety of shots, varying from full-face close-ups to an intricate tracery of foliage.

3. PERFORMANCE

In the sub-sections which follow, detailed appraisals are given of the performance of the newer production camera as observed on the Philips R,G,B colour monitor. No further account will be taken of the SECAM pictures or those of the earlier plumbicon camera which was operating with the original wall anode potential. Where a subjective grade is stated, the quality of the picture from the point of view of the parameter under consideration is given by means of the six-point quality scale as follows:

QUALITY SCALE

Grade	Picture Quality
1	Excellent
2	Good
3	Fairly good
4	Rather poor
5	Poor
6	Very poor

3.1 Picture Sharpness

This quality is dealt with first because it was this feature of the new three-tube plumbicon camera which was the most striking of the appraisal. The subjective sharpness of the plumbicon camera on the R,G,B display was most impressive and in the opinion of the BBC personnel present was, in fact, the best colour picture they had ever seen.

General scenes in the paddock were graded better than 2.0 for resolution. The frequency bars of a test card were resolved as follows:

100 - 300 lines	Fully resolved.
400 lines	Clearly resolved.
500 lines	Distinguishable but of low modulation.
600 lines	Not resolved.

(The number refers to lines in the system, and the number of picture elements along the line would be $\frac{4}{3}$ times this value).

To gain some idea of the improvement in resolution of the new camera over the older one, a comparison was made of a general view of the race course buildings. At six times picture height, the resolution of the new camera was rated grade 1 while the older camera with 300 V wall anode was rated grade 3.

3.2 Registration

We were informed that the registration of the new camera had been adjusted at 11.00 a.m. and had been checked, but not altered, at 1 p.m. At 2.30 p.m., 3½ hours after line-up, the picture was graded 1½ for registration on a scene comprising white railings with staircases and architectural detail.. When the colour monitor was switched to a common drive to all three guns, the picture was still graded 1½. This does not mean that the camera was without registration error but it does mean that they were sufficiently small to be added to the picture monitor errors without causing further degradation. When the camera was panned through 360°, the registration, at the least favourable azimuth, was rated grade 3. With the camera tilted by about 30° from a position in which the registration was graded $1\frac{1}{2}$, the quality of registration dropped to grade $2\frac{1}{2}$. These losses of registration are probably attributable to the effect of the earth's field; the three plumbicon tubes lie in a vertical plane but with their axes at 73° to each other. The misregistration could, however, have been due to magnetisation of the iron railing and steps which were very close to the camera.

During the afternoon, a very heavy shower of rain occurred quite suddenly and some water penetrated the camera, causing a loss in amplitude of the line scan of the green tube. This effect was cured by drying the interior of the camera but until re-adjustment had been carried out, there was a fairly visible colour fringe in the picture. This may have been due to a hurried attempt to restore the registration before it was realised that the rainwater was causing a fault condition. An interesting point which arose was that although the colour fringing was very noticeable, the overall picture still remained outstandingly sharp. This was different from other experiences of the effects of misregistration and is attributable to the fact that the observation was being carried out on an R,G,B monitor. In a misregistered R,G,B picture, the positional errors are all depicted with wide bandwidth and this has three effects:

a) Colour fringing resulting from a given spatial misregistration in the camera is much more noticeable in the R,G,B display due to the clearly-defined transitions.

b) In a colour display where the signals have been obtained from a luminance signal and colour difference signals, misregistration is quickly observed as a loss of resolution in the luminance signal. This is because the E_Y' signal is limited in bandwidth and the sum of the misregistered signals has its harmonics removed. In a misregistered R,G,B display, matrixing of the three signals is by the eye and the same band limitation considerations do not apply.

c) The apparent sharpness of a misregistered R,G,B picture is helped by colour discrimination. (Some work in 1958, see Research Department Report No. T-068, shows where the luminance and chrominance components are separately available, either may be the wide-band signal with the other restricted to a narrow band. It is usual for the luminance signal to be wide-band on account of compatibility requirements but it is not essential to have the high-definition information in the luminance signal when colour pictures only are considered).

Hence a test of registration for a colour camera is much more severe if it is observed on a directly-fed R,G,B monitor than after coding and decoding. Where, however, it is desired to appraise the loss of luminance resolution due to misregistration, this should be carried out on coded/decoded signals. At Longchamp, the SECAM compatible picture was not ideal for this purpose, due to pronounced subcarrier patterns, but because the visible misregistration was small in the R,G,B colour picture and its sharpness was excellent, a satisfactory sharpness of the compatible picture can be assumed.

Even on the severe R,G,B monitor test, the registration of the Philips camera was very good indeed until it was panned to one specific azimuth. After the races had finished, a test was arranged in which a wooden pole was tied to the top of the camera and a registration chart suspended in front of the lens from this pole. Rotation of the assembly showed that a misregistration amounting to about ½ picture element occurred through one 90° sector ~~and~~ of azimuth. Clearly the magnetic screening of the camera requires further attention and this was pointed out to the Philips' engineers who were present and saw this test. The fact that the camera was not completely shower-proof hardly needed emphasis.

Where the camera was deliberately over-exposed, there was some beam-pulling on whites and this showed as loss of registration with colour fringing but everything returned to normal when the correct exposure was regained. The peak white signal limiters were effective in dealing with very bright highlights and introduced no detrimental effects. It was noted that the Philips' engineers needed only a few minutes to re-adjust registration after it had been lost due to the fault condition and that after the adjustment it still rated grade 1½.

3.3 Colour Reproduction

On general scenes, the colour reproduction of the Philips camera was very acceptable. None of the colours appeared to be lacking in credibility, although, of course, it was known that the objective accuracy of the camera plus monitor was at least limited by the use of the new sulphide phosphors.

> On general scenes, the colour reproduction of the camera-plus-monitor (new sulphide phosphors) was graded 2.0.
>
> On saturated colours red and blue (a close-up of jockeys' colours) the picture was graded 3.0.

On the E.B.U. test fabric colours (made up into a flag with the same layout as electronic colour bars), gradings were as follows:

Colour	Grade	Comment
White	1.0	Excellent.
Yellow	1.0	Excellent.
Cyan	3.0	Tending to blue.
Green	2.5	Rather yellow.
Magenta	3.0	De-saturated.
Red	4.0	Too dark.

The E.B.U. cyan is not reproduced well by any camera so far examined nor by any colour film process. It appears to defeat the conventional analysis characteristics.

The rather unsatisfactory red is, of course, most probably attributable to the low red-sensitivity of the standard plumbicon. This shows up to disadvantage in special tests of high saturation colours but the lack of red sensitivity is much less noticeable in general scenes.

The errors observed in the green and the magenta are less severe and they will no doubt be explained when the performance of the colour splitter system at present being measured in Research Department is known in detail.

No blemishes were observed on any of the three tubes fitted to the new camera; a small blemish was, however, visible on the blue tube of the older camera, but it was not objectionable.

3.4 Noise

In the plumbicon camera, the signal-to-noise ratio is determined by the light energy incident upon the photo-cathode. The most efficient division of light energy in the optical colour analysis can only be such that the signal currents in the three tubes are unequal. For example, the green tube signal current may be four times that of the red tube unless neutral density filters are added to its light path. In conditions of ample illumination, this is a desirable procedure since it allows the improvement of signal-to-noise ratio in red and blue channels without overload of the green tube. A 40% transmission neutral filter had been added into the green channel of the camera at Longchamp; this had apparently overshot the requirements since the signal-to-noise ratio in this channel was slightly worse than that of the red and blue channels. It is, however, usual to use less aperture correction in the case of the low luminance primaries and this could account for differences in the signal-to-noise ratios. Subjective quality of the picture from the point of view of freedom from noise was as follows:

Large-area saturated red (E.B.U. fabric)	2.0
Large-area saturated green (E.B.U. fabric)	3.0
Large-area saturated blue (E.B.U. fabric)	2.5

The individual signals, judged by eye on the black-and-white engineering monitor, were of the order of 37 dB peak signal on r.m.s. noise.

This noise performance was held throughout the entire experiment, all variations in light level being compensated by means of the lens aperture control without adjustment of gain or beam current.

3.5 Sensitivity

The sensitivity of the camera appeared to be very satisfactory indeed. As stated above, the camera continued to give very satisfactory pictures throughout the afternoon in weather conditions that varied from bright sunlight to heavy shower. At our request, the camera was kept working after the racing had ceased and we continued to observe the performance until dusk was falling. The lens reached its maximum aperture when the incident light to the scene had fallen to 30 ft-Candles.

It is of interest that measurements of the colour temperature of the light incident varied from approximately 5,500°K to 3,700°K during the course of the afternoon and evening and although no gain control adjustment of any sort was made, there was never any obvious need to re-adjust colour balance. The picture displayed on the R,G,B monitor was at all times credible and if the light towards the end of the day was such that the white point had moved towards red, it did nothing to destroy the verisimilitude of the picture.

3.6 Mechanical Properties

The production version of the three-tube plumbicon camera is of a compact, business-like design, rugged and easy to service. It is not proposed to go into any detail of the services or connections required since this information is readily available elsewhere. The French cameramen had no previous experience of the camera and yet they found it easy to use and spoke very highly of it. It seems probable that the weight could be reduced by the introduction of less rugged covers without reducing the mechanical strength of the camera and it will clearly be necessary to make at least some minor modifications to improve the shower-proofing of this instrument.

4. CONCLUSIONS

The picture quality produced on an R,G,B monitor by this camera surprised the BBC engineers by its outstanding sharpness. The resolution obtained with new scanning yokes and higher wall anode potentials is clearly much [redacted] superior to that which has been seen in earlier cameras. The registration was also very good, although this cannot yet be regarded as completely acceptable. The colour reproduction of the camera is acceptable but it is not difficult to demonstrate fairly substantial errors. These will be reduced when the red-sensitive tube becomes available and it may well be that measurements of the optical beam splitter will reveal other details which may be improved. The sensitivity of the camera appears to be adequate for all reasonable purposes and the way in which the camera reproduced colour scenes with only 30 ft-Candles incident light was impressive. When a few modifications have been incorporated, this camera should set a high standard of performance.

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